# REPORT

ON

# SHIP CANAL

FROM

# TAUNTON RIVER TO BOSTON HARBOR

BY THE

BOARD OF HARBOR AND LAND COMMISSIONERS.

UNDER RESOLVES OF 1901, CHAPTER 104, AND RESOLVES OF 1902, CHAPTER 82.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
18 POST OFFICE SQUARE.
1902.

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## Resolves of 1902, Chapter 82.

*Resolved*, That the board of harbor and land commissioners is hereby authorized and directed to prepare, on or before the first day of May in the year nineteen hundred and two, a report of its survey of the proposed canal from Taunton river to Weymouth Fore river, and to have five hundred copies thereof printed. The said report shall include such maps as the board may deem necessary, a statement of the cost of making the proposed canal, and a statement of the expenses incurred by the board in making the survey. The cost of printing the report shall not exceed the sum of one hundred dollars, and shall be paid out of the sum appropriated for the said survey. A copy of the report shall be delivered to each member of the general court, and a copy shall be sent to each representative and senator from Massachusetts in the congress of the United States. [*Approved April 30, 1902.*

# Commonwealth of Massachusetts.

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Boston, May 1, 1902.

The Board of Harbor and Land Commissioners, pursuant to the provisions of Resolves of 1902, chapter 82, submits the following report on its survey of the proposed canal from Taunton River to Weymouth Fore River.

Chapter 104 of the Resolves of 1901 directed the Board to make surveys and estimates as to the probable cost of constructing a ship canal from Narragansett Bay through Taunton, Brockton and Weymouth to Boston harbor, by way of Weymouth Fore River, and to report thereon to the General Court now sitting.

The depth and width of the proposed canal were apparently left to the judgment of the Board. A uniform depth of 25 feet and a width of 130 feet on the bottom, with side slopes of 1 on 2 in earth, and 180 feet with vertical sides where rock is encountered, have been fixed for the dimensions of the trunk of the canal.

A general location was determined from a study of the topographical maps, base lines were run, and a topographic and hydrographic survey was made for a distance of not less than 500 feet on either side for the entire distance from Weymouth Fore River to Slade's Ferry bridge near the mouth of Taunton River, with levels on the same and on cross-sections 500 feet apart. Other necessary levels were run and tidal observations made. The plane of reference of the survey was established at 1.5 feet below the mean sea level at Boston.

The results of these surveys were plotted on large scale plans, and contours drawn, showing every difference of 2 feet in elevation over the area surveyed. After a careful study of the information accumulated, a route was finally adopted.

The total length of the canal upon which the estimates are based between the ends of the approach structures of the tidal locks is 31.79 miles, of which 7.24 miles are on curves, the radii varying from 5,000 to 10,000 feet, and 2.22 miles of shorter radii, none, however, less than 2,000 feet. In fixing the line, due regard was had to economical construction.

Provision is made for 14 locks, 6 between Boston harbor and the summit level and 8 between there and the dam in Taunton River, with lifts varying from 7 to 25 feet. On the basis of 20 lockages a day, 33,000,000 cubic feet of water will be required for the daily operation of the locks.

A careful examination of the water supply and of the different methods of providing the necessary amount of water led to the adoption of a pumping system, as being the most advisable. The water surface of the summit level lies between Brockton and Randolph. The summit level is 16,000 feet long, at an elevation of 130 feet.

Two masonry dams are planned at the two ends of the canal, across Taunton River and Weymouth Fore River, respectively, opposite the tidal locks, to maintain the water in the rivers at high tide level.

The proposed line of the canal crosses the railroad at eleven places; it is proposed to avoid five of these by diverting the location of the tracks, and two of the others are drawbridges at the present time. It also crosses forty-six highways, of which a number are avoided by a rearrangement in such manner that the distance to be travelled will not be materially increased. Twenty drawbridges will cross the canal in most of which a clear width of 100 feet is provided for the passage of vessels.

Wherever the water level of the canal rises above the adjacent country, the side embankments are planned with puddle walls of clay; but where it runs through earth, a protection of broken stone, extending from 5 feet above to 5 feet below the water level, will be provided. Turning basins are proposed at Taunton, Brockton and Holbrook, approximately 600 feet square.

The cost of a sufficient right of way has been estimated. All estimates are based on unit prices, carefully considered;

and yet allowance must be made, owing to the brief time permitted for the examination of so large an undertaking. The total cost is estimated at $57,618,358.

A full report by the engineer of the Board, together with plans of location and profile, may be found in the Appendix.

*Expenses of Survey, under Resolves of 1901, Chapter 101, up to May 1, 1902.*

| | |
|---|---|
| Services of engineers, | $6,762 92 |
| Board of employees, | 1,824 88 |
| Travelling expenses, | 529 21 |
| Surveying instruments and repairs, | 411 30 |
| Labor, | 431 90 |
| Boat hire, | 44 06 |
| Carriage hire, | 114 50 |
| Drawing materials, | 25 00 |
| Expressage, freight, etc., | 15 83 |
| Hardware, tools, etc., | 35 87 |
| Lumber, | 12 24 |
| Maps, | 10 00 |
| Rubber boots, | 85 50 |
| Stakes, | 61 64 |
| Stationery and office supplies, | 22 40 |
| Sundries, | 35 60 |
| Telephone and telegrams, | 18 89 |
| | $10,441 74 |

NOTE. — Of the above, $900 was for salaries of regular employees of the Harbor and Land Commission detailed on this work, and was paid from the office appropriation.

The foregoing report is respectfully submitted.

WOODWARD EMERY,
CHARLES C. DOTEN,
GEORGE E. SMITH,
*Commissioners.*

# APPENDIX.

# REPORT OF ENGINEER ON TAUNTON RIVER AND BOSTON HARBOR CANAL.

BOSTON, Jan. 20, 1902.

*To the Board of Harbor and Land Commissioners, State House, Boston, Mass.*

GENTLEMEN: — In accordance with your instructions, I have had surveys and estimates made as to the probable cost of constructing a ship canal from Narragansett Bay to Boston harbor through Taunton River and Weymouth Fore River, under chapter 104 of the Resolves of 1901: —

*Resolved*, That the board of harbor and land commissioners is hereby directed to make or cause to be made surveys and estimates as to the probable cost of constructing a ship canal beginning at some convenient point on Narragansett bay and Taunton river, harbor or estuary thereof, and extending across the state of Massachusetts through the cities of Taunton and Brockton and the town of Weymouth to Boston harbor by way of Weymouth Fore river. For this purpose the board may employ an engineer or engineers and other assistants, and may expend a sum not exceeding ten thousand dollars. The board shall report to the general court not later than the fifteenth day of January in the year nineteen hundred and two. Whatever amount is expended by the board for the purpose authorized by this resolve shall, in the event of the granting of any charter or franchise for the construction of a canal between the points above specified, be repaid to the Commonwealth by the grantee or grantees of such charter or franchise. [*Approved June 13, 1901.*

The statute simply provides for the surveys and estimates for a ship canal, without in any way indicating the size of ships to be provided for; but it limits the location by providing that it shall pass through the cities of Taunton and Brockton and through the town of Weymouth.

The plan adopted for the investigation is as follows: First, to determine the general character and dimensions of the canal, and where it could probably be located. Then the field surveys were undertaken, under the general supervision of Mr. Henry B. Wood, with Mr. Eugene E. Pierce, Mr. A. D. Butterfield and Mr. L. H. Bateman in immediate charge of the different survey parties; and

in the office Mr. John R. Burke, Mr. W. W. Marrs, Mr. T. W. Bailey and Mr. E. W. Hadcock were employed in the preparation of the plans and estimates, the field note books being sent to the office, and the plans prepared as soon as the books could be spared from the field work.

Mr. F. W. Dean, Mr. S. E. Tinkham, Mr. Henry D. Woods and Mr. E. L. Brown have made estimates and examinations as to pumping, machinery, bridges, mechanical lift locks, and the nature of the soil through which the canal is to be constructed.

Upon the completion of the field surveys, Mr. D. J. Howell, who had been engaged as assistant engineer on the surveys and in preparing the report of the United States Board of Engineers on deep water ways from the Great Lakes to the Atlantic coast, and as consulting engineer in charge of the surveys and estimates for a barge canal from the Great Lakes to the Hudson River, under the direction of Hon. Edward A. Bond, State engineer and surveyor of New York, was engaged to assist in the preparation of the plans and estimates. Mr. Howell brought to the work a great fund of information collected during his work on the New York investigations, and to this is due much of the completeness of this report; as, owing to the limited time after the completion of the field work, it would otherwise have been impossible, with the small appropriation available, to prepare the necessary plans and estimates, — and, as it is, much is lacking, owing to our inability, through lack of means, to make borings and do other work necessary to obtain a complete knowledge of the facts.

My first endeavor was to determine the size of the canal which was required, and at my request you addressed a letter to Mr. Parker C. Chandler, who had been prominent in advocating the passage of the resolve through the Legislature, asking him for any information he had bearing on the subject under investigation, and also as to the size of the canal desired by the petitioners. In his reply he stated that considerable information might be obtained from documents in the State Library, and referred to the report of the committee of the Legislature who explored a line for a canal over this route, and made a report on the same in February, 1808. He also stated that reports had been made by officers of the general government on the same subject; and a copy of a report made by the Board of Internal Improvement and transmitted to Congress by the Secretary of War on Feb. 16, 1825, on the proposed canal from Barnstable Bay to Buzzards Bay, and also on a general examination of the route from Narragansett Bay to Boston harbor, has been found. This report stated that a general and thorough survey of this route appeared to be wanting.

A copy of a portion of a plan made by the United States Topographical Engineers in 1833, from a detailed survey of the portion of the route from Boston harbor to Brockton, has also been found; but the report of the engineers on this survey we have not been able to find up to the present time, although search has been made for it in the State Library and at the office of the Chief of Engineers at the War Department at Washington.

In regard to the size of the canal, Mr. Chandler stated that it was the intention of the petitioners to have that matter left open, so that the commissioners would study the matter and decide as to the size of the canal which would be required by modern vessels. He also stated that the general government had comprehensive plans for a scheme of inland navigation stretching along the coast line from Boston harbor to Florida, and the line from Boston harbor to Narragansett Bay was one link in this scheme. He also called attention to the various forms of mechanical lifts which had been designed and in some cases put in successful operation to take the place of the ordinary canal lock; and also to the modern machinery which had been designed for the construction of canals, thereby greatly reducing their cost, and also stated that the project for this canal would be called to the attention of the next Congress. He promised at the same time to forward several books, documents and maps which would be of service, but he was unable to do so.

As his letter did not give information as to the size of the canal required, in seeking other sources of information as to this question, letters were addressed to the Secretary of the Navy and the Secretary of War, asking what plans the government had in relation to water ways along the Atlantic coast, and especially between Narragansett Bay and Boston harbor, and as to the size of any proposed water ways in this location, also for such opinions as might have been expressed by any of the officers of the Engineer Corps or of the Navy as to the dimensions which such a water way should have.

The Secretary of the Navy in replying simply stated the dimensions which had been adopted in 1884 for a projected canal from Barnstable Bay to Buzzards Bay, and the dimensions of the Kaiser Wilhelm Canal and the Suez Canal, stating that this was all the information on file in the department which it was deemed would be of value to us.

The letter to the Secretary of War was referred to the Chief of Engineers, and in his reply he stated that no plan had been formed by the federal government for a system of internal water ways along the coast from Maine to Florida, but that a number of inland

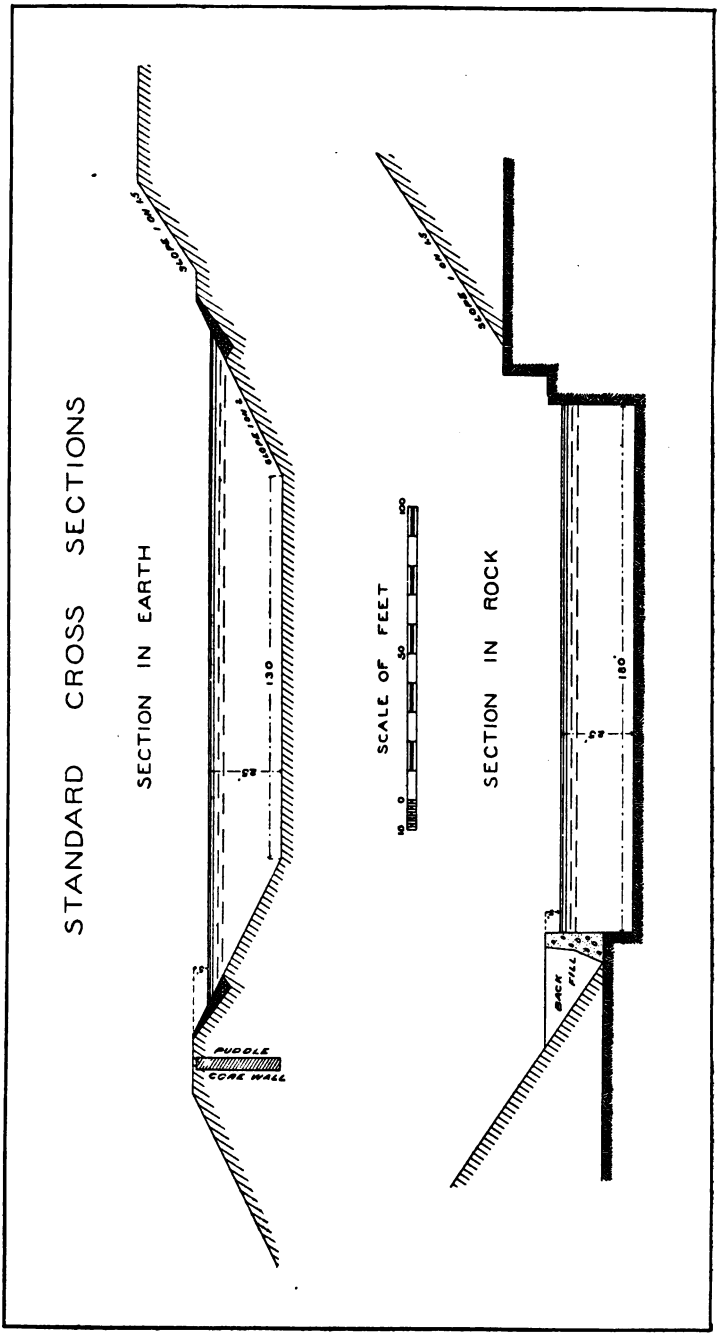
routes are being improved, under appropriations made by Congress, between Delaware Bay and Florida, and that surveys for others within the same limits had been made, and forwarded copies of the latest reports on these works. On examination of these documents, it was found that all the water ways now under improvement are for light-draft vessels, and the only information as to such a ship canal as is proposed in the case under consideration was in a report made in 1894 on a survey for the Chesapeake and Delaware Canal, which was to connect Baltimore harbor with deep water at the mouth of the Delaware River. This was to be a canal 100 feet wide on the bottom and 26 feet deep at low water.

In view of the fact that the statute incorporating the Boston, Cape Cod & New York Canal Company, in 1899, fixed the dimensions of this canal as depth 25 feet and bottom width not less than 100 feet, it was decided that it would not be wise to adopt any smaller dimensions. A depth of 25 feet is sufficient to float the vessels engaged in the coastwise traffic, and, with the width of 60 feet in the locks, any of the naval vessels, except battle ships, could pass through.

In order that the canal shall have sufficient cross-section to enable vessels to pass through at a fair rate of speed, the width has been made 130 feet on the bottom, with the side slopes 1 on 2, for all sections where it is expected earth will be found; but where rock is encountered, the section will be 180 feet wide, with vertical sides. This gives cross-sections about four times greater than the midship section of the largest vessel which could safely navigate a canal of this depth, and is about the same as that of the Manchester Ship Canal. In this width the ordinary coastwise steamers could safely pass in any place with only a slight reduction in their normal speed through the canal.

Having fixed the dimensions of the trunk of the canal, search was made for an approximate location, using the plans of the State topographical map. A study was made on this map of the different lines which had been suggested at different times by various parties, among them the lines shown on the lithograph plan presented to the Legislature by Mr. Chandler, and the two lines surveyed by the United States Topographical Engineers between 1821 and 1833.

All the lines surveyed along this general location except the present scheme have been for small barge canals, and it was found that the general course followed by these would be the best for the proposed ship canal. In general, the line selected starts in Weymouth Fore River, a short distance above the bridge at Quincy Point; thence follows the valley of the river to Weymouth land-


STANDARD CROSS SECTIONS
SECTION IN EARTH
SLOPE 1 on 2
SLOPE 1 on 2
130
PUDDLE
CORE WALL
SCALE OF FEET
0
50
100
SECTION IN ROCK
SLOPE 1 on 2
180
BACK FILL

ing; thence up the valley of Smelt Brook a short distance, crossing the south shore branch of the Old Colony Railroad at Weymouth landing and the main street of the town close to the East Braintree boundary line; thence continuing up the brook and through the divide into the valley of the Monatiquot River; thence following up this valley, crossing the Plymouth & Whitman branch of the Old Colony Railroad and the present main line of the Old Colony Railroad just south of the South Braintree station; thence across Dyer hill, following along the Cochato meadows and crossing the Taunton branch railroad opposite Mayflower Park, and the line of the Cape Cod branch railroad about 3,000 feet north of Holbrook station; thence keeping a short distance east of the railroad and passing through the divide near Avon station into the valley of Trout Brook, and along the valley of this brook and Salisbury Plain River through the city of Brockton, crossing the Middleborough section of the Plymouth division of the New York, New Haven & Hartford Railroad a little south of Campello station; thence through the divide between the valley of the Salisbury Plain River and Town River, crossing the West Bridgewater branch of the Old Colony Railroad; thence along the valley of Town River, passing through Hockanock swamp, Nippinicket Pond, and the divide into the valley of the next stream south, a tributary of the Taunton River, which runs through the village of Raynham; thence down the valley of this stream and the Taunton River to Weir village in the city of Taunton, and thence following the Taunton River to its mouth in Mount Hope Bay.

The general location having been determined from the study of the maps, two parties were organized for making a detailed survey of the location. Base lines were run and the topography and hydrography surveyed the whole distance from Weymouth Fore River to Slade's Ferry bridge near the mouth of Taunton River. In general, the base line followed the line of the proposed canal, and the topography was surveyed for a distance of not less than 500 feet on either side of the line. The angles in the base line were connected with the triangulation stations of the town boundary survey, and in this way the whole work was checked and errors avoided. At a number of places where there appeared to be a choice as to the best location, the surveys extended over a considerably greater width.

Levels were run the whole length of the base lines, and on cross-sections every 500 feet; these levels furnished points from which the topographic parties could check their work. In addition, a line of precise levels was run from Somerset to Weymouth landing, following the line of the railroad and highways, connect-

ing at frequent intervals with the line of levels run along the base lines. At the same time, tidal observations were made at both ends of the canal, and compared with the benches of the United States Coast Survey. From these levels, adopting the mean sea level calculated from the observations of the Coast Survey at Boston, it was found that the plane of reference of the survey was 1.5 feet below mean sea level at Boston, while the mean water level at Somerset was a few tenths of a foot higher than that at Boston, due probably to its distance up the river from the sea.

The difference in elevation of the various benches, as determined by the line of precise levels and the line run over the base line, did not vary at any point more than .3 of a foot. Many bench marks were established along the line of these levels, which will probably be found useful in future work. The results of these surveys have been plotted on a series of 24 sheets, each 30 by 52 inches, on a scale of 1 to 2,000, and one sheet about the same size on the scale of 1 to 5,000. On the large scale sheets contours were drawn showing every 2 feet difference of elevation, and on the sheets thus prepared the centre line of the proposed canal was located.

A diligent inquiry was made for information as to borings which had been made for any purpose along the line of the proposed canal, and as to the character of the material through which the wells in the vicinity had been dug or driven, also the same information in relation to other excavations. The outcrop of all ledges along the line of the survey were located by the survey parties, so that, although unable to make any borings of our own, sufficient information was obtained to give a very fair idea of the character of material to be excavated, and on what material the various structures would probably be founded.

Information furnished by the city engineers of Brockton and Taunton and by Mr. Edward Parrish of the United States Engineer Office at Newport was of much value in this part of the investigation, and other parts of the work were very much facilitated by using the plans and data furnished by them and others.

South of Brockton, in addition to the route finally adopted, surveys were made over a route crossing the divide to the west of Campello station, and following down the valley of Black Betty and West Meadow brooks, rejoining the original route at Skimmilk bridge, a short distance north of Nippinicket Pond. This route would have avoided the necessity of going directly through the village of West Bridgewater, but after considering the two, the easterly one was adopted as preferable. At the northern end an alternative route from South Braintree to the Weymouth Fore River was to follow the valley of the Monatiquot River from South

Braintree to Braintree; thence across the country to a point in Weymouth Fore River just south of the new works of the Fore River Ship and Engine Company. On the maps this appeared to be quite feasible, but, as it did not enter the town of Weymouth, as is required by the statute, it was not surveyed.

South of Taunton the line follows the general location of the Taunton River; but, owing to the sharp curves in the river, it was found necessary to cut through the bends in many places in order to get such an alignment as would enable large steamers and barges to safely navigate the new channel. It is planned to establish tidal locks at each end, the one in the Taunton River to be located just north of the village of Dighton, and the one at Weymouth Fore River on the westerly bank of the river, about opposite the northerly end of White's Neck. Between the tidal locks are 12 other locks, with lifts varying from 16 to 25 feet.

*Alignment.*

The total length of canal on which the estimates are based between the ends of the approach structures of the tidal locks is 31.79 miles; of this, 22.33 miles is straight, and the balance, 9.46 miles, on curves of radii varying from 2,000 to 10,000 feet, only 2.22 miles having radii of less than 5,000 feet.

On all curves of less than 10,000 feet radii the width of the canal was increased by an amount determined by the following formula: $60 - .005 \times$ radius, all dimensions in feet, the additional width being added one-half on each side at the middle of the curve, and tapered to nothing at the tangent points.

The canal line was located where, from all the information obtained, it appeared that the canal could be most economically constructed within the limits prescribed by the resolve. Further investigations and borings to determine the character of the material through which it is to be built and on which the various structures are to be founded will undoubtedly show the advisability of some changes in the location of the canal and its various structures; but any changes which are liable to be made will not, in all probability, materially alter the total cost.

*Northern Approach.*

At the northern end of the canal deep water is found at the mouth of Weymouth Fore River, about $2\frac{1}{2}$ miles below the bridge at Quincy Point. This channel is the approach to the works of the Fore River Ship and Engine Company; and in making the estimates it has been assumed that it would be enlarged and deepened by the general government as an approach to these

works, and the cost of doing this work has not been included in the estimates for the canal.

Between the bridge and the tidal lock (a distance of about 1 mile) the estimates are for a channel substantially 500 feet wide and 25 feet deep at mean low water, the width being much greater than at any other portion of the canal, owing to the very sharp curves which it is necessary to introduce.

The most natural location for the purposes of navigation would have been to excavate a channel across the neck of land known as Old Spain, which would have given practically a straight channel from the mouth of the canal into the lower part of Weymouth Fore River. No estimates have been made for this, as it did not seem that the increased facilities for navigation would be sufficient to justify the greatly increased cost.

The plans of the general government for the improvement of the Weymouth Fore River are simply to obtain a channel from a point about opposite the proposed entrance lock of the canal up to the head of navigation, not less than 6 feet deep at mean low water, and of a width varying from 100 feet to 50 feet. This has been substantially completed, and no plans have been adopted for any further improvement.

*Southern Approach.*

At the southern end of the canal deep water is found in Mount Hope Bay just below the point where the line between Massachusetts and Rhode Island crosses it. Above this in Fall River harbor and between Fall River and Somerset there are long sections where the channel is more than 25 feet deep for a width of not less than 300 feet, but there are bars crossing it at a number of places. The plans of the general government contemplate the excavation of a channel 25 feet deep at mean low water and 300 feet wide through these bars up through Fall River harbor to Slade's Ferry bridge. From this point nearly up to Somerset, a distance of 3 miles, the channel is continuous, and of sufficient width and depth; from thence up to the entrance lock, a distance of 4.5 miles, the channel will have to be excavated to a depth of 25 feet at mean low water with a width of 300 feet. The plans of the general government at present contemplate the deepening and widening of the channel so as to secure a depth of at least 12 feet at high water, with a width of 100 feet up to Berkley bridge; thence the same depth and 80 feet wide up to Briggs shoal; thence 11 feet in depth with the same width up to the ship yard; thence 11 feet depth with a width of 60 feet up to Weir bridge at Taunton. These plans have been practically completed. The work remaining to be done

consists of the removal of a small amount of ledge and some dredging below Berkley bridge. In making the estimates it has been assumed that the general government will carry out its plans and excavate the channel up to Slade's Ferry bridge, and the estimates include only the work of dredging the channel from the deep water below Somerset to the tidal lock.

*Style of Lock.*

In a canal of this size the question of the water supply is a very serious one, especially in a flat country, where the drainage areas tributary to the canal, especially those above the elevation of the summit level, are not large.

The ordinary form of lock to accommodate vessels of the size which may be expected to use a canal in this location requires the discharge of a very large volume of water from the upper level into the lower level whenever a vessel passes from one to the other. This loss from the upper level must be supplied from some source. In order to avoid the necessity for such a great loss of water, various mechanical devices have been designed. Many of these have been used on barge canals, but I know of no case where they have been used on a canal as large as the one now under consideration. In addition to the saving of water, these mechanical appliances are designed to be used for much higher lifts than the ordinary lock, so that each one will take the place of a number of the ordinary type, with a corresponding decrease in the length of time required for a vessel to pass from one level to another.

These mechanical appliances are of different types. The earliest, known as chain lifts, consisted of a wooden or metal box with gates at each end, filled with water, and large enough to contain the largest boat using the canal. To this were attached a number of chains which passed up over pulleys mounted on framework, the other ends of the chains being connected with counterweights sufficient to counterbalance the weight of the box full of water. After the boat was placed in the lock and the gates closed, sufficient water was either drawn into or from the box to make it heavier or lighter than the counterweight, so that it would either drop or rise, as required, to the other level of the canal.

Next come the various kinds of hydraulic lifts. These also consist of boxes or tanks sufficient in size to contain enough water to float vessels using the canal, and they are raised or lowered by hydraulic rams, which are either placed directly under the box or alongside it; in the latter case, the ends of the rams carry large pulleys over which pass chains or wire ropes, one end of which is

attached to the press of the ram, the other to the side of the lock. These are ordinarily constructed in pairs.

The third form is the floating lift, which consists of one or more tight tanks floating in a deep pit, and supporting above them on trestle work the box of the lock. The floats being submerged, it requires the application of a small amount of power to raise or lower the lock.

The fourth form is the pneumatic lock, which consists of an inverted tank in a pit filled with water. On the top of this tank is the ordinary lock box, with gates at the ends, filled with water. These locks are designed to be used in pairs, the two inverted tanks being connected by large pipes, and the air passing from one to the other as the locks are raised and lowered, one rising as the other lowers.

The first three styles have been used in various forms in this and European countries, but so far as I have been able to learn, the pneumatic lifts have not been in use as yet.

Mr. Woods's notes, describing the various lifts which have been designed or built, are hereto annexed.* From the results of this study, and as the heights of the lifts in the canal under consideration are well within the range of work which has already been constructed, and as the construction of mechanical lifts of this size would be somewhat of an experiment, none having actually been constructed, it has been decided that for the purpose of this estimate it will be better to provide for using the ordinary style of lock.

*Water Supply.*

Having decided to base the estimates on the ordinary style of lock, the question arises as to where the necessary water supply can be obtained.

The number of vessels arriving at Boston from southern ports in 1900, as stated in the annual report of the Boston Chamber of Commerce, is as follows: tugs, 1,235; steamers, 1,083; barges, 2,817; total, 5,135, — an average of about 14 per day. If these all came and returned through the canal and passed through the locks singly, it would make 28 lockages per day; but, as the arrivals are not regular, and the locks being large a number can pass through at one lockage, it has been deemed best to assume 20 lockages per day of the full-sized locks as a basis on which to calculate the supply of water required. All of the locks north of the summit level of the canal except the tidal lock have lifts of practically 25 feet each. The locks south of the summit

* Not printed.

level vary from 16 feet to 21 feet lift, and, on the basis of 20 lockages each day, it will require 30,000,000 cubic feet of water daily to operate the locks.

As the canal is located so as to be generally below the ground-water level of the surrounding country, the loss of water from seepage would probably not be large. To provide for this and for the leakage through the lock gates and culverts, it is estimated that 3,000,000 cubic feet per day will be required, making the total amount of water required 33,000,000 cubic feet per day.

There is no drainage area near the location of the canal which will supply such a large quantity of water at an elevation above the summit level, and such small portions as are at the necessary elevation are largely used at the present time in supplying the population in their vicinity with water for domestic use. The stream which most nearly meets the required conditions is the Blackstone River. This has a drainage area above the dam at Millville in Blackstone of 258 square miles; and, if all the water from this drainage area can be intercepted and stored, it would nearly supply the demands of the canal, on the basis of 20 lockages per day of the full-sized locks. The river at Millville is about 70 feet above the summit level of the canal, — a sufficient elevation to enable the water to be diverted into it.

An aqueduct capable of conducting the water would be about 30 miles long, and would have to be built very largely in tunnel. It would be very nearly straight, and would pass along the southerly side and near the summit of the main divide, separating the streams which flow northerly into Boston Bay and southerly into Narragansett Bay, crossing nearly all the valleys which it intersects substantially at right angles.

Owing to the configuration of the country, it would be difficult and expensive to construct reservoirs to store all the water on this water-shed. For this reason, another method of furnishing the water supply was investigated, viz., to pump it from the Weymouth Fore River at the northern end of the canal up into the summit level. For this purpose four sets of pumps would be required: one set to pump from the river directly into the level above lock No. 3; another set to pump from the level below lock No. 4 into the level above the same lock; the third to pump the water from the level below lock No. 5 to the level above the same lock; and the fourth to pump from the level below lock No. 6 into the summit level.

Owing to the large quantity of water to be raised, the estimates have been made for furnishing a steam plant at each pumping station, as being cheaper and more reliable than generating the power at one station and distributing it by electricity. The first cost of

the pumping plant is very small compared with the cost of furnishing the water from the Blackstone River, but the operating expenses are very large. Upon comparing the two estimates on the basis of capitalizing the operating expenses of both systems, the pumping system was found to be the least expensive. Moreover, the pumping system would be more compact, and there would be much less disturbance of local conditions.

One serious objection to the use of the water from the Blackstone River is its polluted condition, it being, according to the reports of the State Board of Health, the most seriously polluted stream in the Commonwealth.

*Locks.*

The highest point on the line of the canal is about 160 feet above mean sea level, and is located just north of the city of Brockton, in Holbrook and Avon; and the water surface of the summit level of the canal has been fixed at elevation 130. The ascent from Weymouth Fore River to the summit is quite regular, and much steeper than the descent to Taunton River.

The estimate provides for 5 locks, each of 25 feet lift, in addition to the tidal locks, to reach the summit level from Weymouth Fore River. The first 2 of these, located at Weymouth landing, are arranged as tandem locks, and are built double. The other 3 locks are built single, and are located on one side of the centre line, so that a companion lock can be built in the future without disturbing the existing one.

Between the summit level and the tidal lock in the Taunton River the estimates provide for 7 locks, with lifts varying from 21 to 16 feet; they are all single locks, arranged the same as the single locks between the summit level and Weymouth Fore River.

The locks are all planned to be 60 feet wide and 550 feet long between the hollow quoins, this length being divided into two chambers, respectively 350 feet and 200 feet, by a set of middle gates. The total length of the lock structure over all is about 730 feet, and the depth on the sill 25 feet. The gates are planned to be of steel, and of the standard mitre form.

In addition to the operating gates, the estimates include guard gates at both ends of all the single locks, and at the foot and head of the combined locks at Weymouth landing; so that, in case of accident, by closing the guard gates the lock may be pumped out and repairs made without interfering with the other portions of the canal.

The estimates for the locks, as well as for the other structures

in the canal, are principally based on the designs and estimates made by the United States Board of Engineers on deep water ways, and on those of the State engineer and surveyor of New York for a 1,000 ton barge canal from Lake Erie to tide water.

*Lock Approaches.*

The estimates provide for the construction at both ends of each lock of vertical walls either of concrete or timber cribs, to guide vessels into the lock and allow for their being tied up awaiting the opening of the gates. These are planned so that, in case an additional lock is built later alongside of the existing one, as small a portion as possible of the existing structures will have to be torn out and rebuilt.

*By-passes. — Waste Weirs.*

The estimates also include the cost of the necessary structures to maintain the level of the water in the canal by discharging any surplus over spillways or waste weirs either into adjacent streams or artificial channels, which will take the water around the various locks into the level below, or waste it into existing streams. These are designed to care for the largest freshet which is likely to occur on the water-shed. It will probably be necessary to enlarge the standard section of the canal in a few places, to enable it to pass the flood discharges; but the time has not been sufficient to go into this matter fully, but, in any event, it will not be a large additional expense.

Estimates have been made for two masonry dams at the two ends of the canal across the Taunton and Weymouth Fore rivers opposite the tidal locks, to impound and maintain at about high-tide level the water in the rivers and tide-level sections of the canal. These, as in the case of the waste weirs of the canal, have been designed to take care of the flood discharges without unduly raising the water level either in the canal or rivers.

*Stream Crossings.*

As the canal generally follows the thread of the streams flowing through the valleys in which it is located, it receives the natural drainage from the water-shed; and, as the water supply of the canal is to be supplied by pumping water from the Weymouth Fore River, the drainage into the lower levels will be discharged through the waste weirs into the streams where they diverge from the line of the canal; and the Town River, which crosses the line of the canal at West Bridgewater, is to be conducted through a

culvert under the canal, so that the water supply to the streams below will not be interfered with. The mills and dams on the streams at South Braintree and Raynham, lying, as they do, directly in the line of the canal, are necessarily destroyed.

*Diversion of Railroads and Highways.*

In planning for the construction of work of this magnitude, it is impossible to avoid interfering with many existing structures. The proposed line of the canal crosses the various lines of the New York, New Haven and Hartford Railroad at eight places, in addition to the existing drawbridges at Somerset and Slade's Ferry, and the freight yard at Brockton. At four of these places the crossing cannot be avoided, and estimates have been made for drawbridges. At the others, estimates have been made for diverting the railroads so as to avoid their crossing the canal.

Forty-six highways now cross the line of the canal. Estimates have been made for 14 drawbridges, and for rearranging the highways and diverting some of them. The plans have been so arranged that the distance to be travelled in most cases will not be materially increased over the distance between the same points by the existing routes.

The railroad bridges are all planned for two tracks, except the one at Campello, which is planned for four. The highway bridges, are planned to carry an electric railway, to have a roadway 34 feet wide, and two sidewalks, the whole to be 50 feet wide over all.

In all cases the clear width for the passage of vessels is to be 100 feet, except in the four-track bridge, and where the bridges are located at the ends of locks; in these cases the clear passageway is to be 60 feet, the same as the width of the locks.

Owing to the sharp angles at which the railroads cross the canal in some places, and at others to the curves in the railroads, it was found necessary to plan slight deviations in the locations of all the railroads but one, in order that they might cross the bridges on tangents, and more nearly at right angles to the line of the canal. The estimates include the cost of a new railroad bridge across the Taunton River at Somerset, as the draw in the present bridge is not adapted for the convenient passage of large vessels.

*Protection of the Walls and Banks of the Canal.*

Wherever the water level of the canal will be above the present surface of the adjacent country, the embankments on the sides are planned to have puddle walls of clay built through their centres; and wherever the banks of the canal throughout its length consist

of earth, the estimates provide for protecting them with a coating of broken stone, extending from 5 feet below the water level of the canal to 5 feet above that level, as shown on the standard cross-section, in order that they may not be injured by waves created by passing vessels.

*Turning Basins.*

In order to enable vessels to enter the canal from either end with cargo for any of the cities or towns on the line of the canal, turning basins or harbors have been provided at Taunton, Brockton and Holbrook, approximately 600 feet square, where vessels may be turned around so that they may return.

In addition to these harbors, wharf walls, to be located at various points along the canal, are included in the estimates.

*Electric Power and Lights.*

The estimates include the cost of an electric power and lighting plant, to be located and operated with one of the pumping stations and the necessary wire lines, lamps and motors, to operate the drawbridges, lock gates and sluices and to light the canal throughout its length.

*Right of Way.*

The cost of sufficient right of way to enable the canal to be constructed without trespassing on other property has been included. The area required is based on the amount of territory required to deposit the material excavated from the canal alongside of the place from which it is excavated, without piling it higher than 10 feet above the surface, and not allowing it to come within 25 feet of the bank of the canal at any point. This general plan has been modified in its application, so that through cities and improved territory a comparatively narrow strip should be taken, generally little more than sufficient for the operation of the canal; and where the land was of less value, larger areas are included, in order to allow room for the deposit of material taken from the narrower sections.

*Unit Prices.*

The unit prices used in determining the value of the work to be done in the construction of the canal are based very largely on those adopted by the United States Board of Engineers on deep water ways, and those used by the State engineer and surveyor of New York in making his estimates for the 1,000 ton barge canal through New York. These have been compared with the prices

paid for work on the metropolitan water system and other works in the vicinity of Boston, and modified as found necessary.

The larger part of the masonry has been estimated as concrete, stone to be used only where the masonry will be subject to wear.

*Estimates.*

Owing to the short time which was available for making up the estimates, and to the uncertainty as to the exact character of the material through which the canal is to be constructed, it has been impossible to make the estimates with the exactness which would have been done if time and means had allowed; and for this reason it has been deemed best to add 15 per cent. to the figures, to cover possible contingencies and unknown quantities, as well as the usual expenses attending any such undertaking. The estimates are as follows: —

*Excavation (including Approaches between Quincy Point Bridge and Slade's Ferry Bridge).*

| | | | |
|---|---|---|---|
| Earth: — | | | |
| 13,115,965 cubic yards, at $0 35, | $4,590,587 75 | | |
| 9,654,478 cubic yards, at 30, | 2,896,343 40 | | |
| 16,357,074 cubic yards, at 25, | 4,089,268 50 | | |
| 2,314,477 cubic yards, at 20, | 462,895 40 | | |
| | | $12,039,095 | |
| Rock: — | | | |
| 4,938,482 cubic yards, at $1 00, | $4,938,482 00 | | |
| 850,434 cubic yards, at 2 50, | 2,126,085 00 | | |
| 100,000 cubic yards, at 10 00, | 1,000,000 00 | | |
| | | 8,064,567 | |
| | | | $20,103,662 |
| Backfill, 4,540,400 cubic yards, at 20 cents, | | | 908,080 |
| Culverts and by-passes, | | | 980,000 |
| Retaining walls, | | | 1,494,660 |
| Puddle walls, | | | 144,317 |
| Wash walls, | | | 1,196,072 |
| Spillways and waste weirs, | | | 815,000 |
| Stop-gates, | | | 300,000 |
| Highway changes, | | | 343,100 |
| Railroad changes, | | | 462,000 |
| | | | $26,746,891 |

*Highway Bridges.*

| | | |
|---|---|---|
| At Weymouth, | $97,000 | |
| At South Braintree, | 101,000 | |
| At Holbrook, | 114,000 | |
| *Amounts carried forward,* | $312,000 | $26,746,891 |

| | | |
|---|---|---|
| *Amounts brought forward,* | $312,000 | $26,746,891 |
| At Avon, | 87,000 | |
| At Montello, | 116,000 | |
| At Ashland Street, | 117,000 | |
| At Center Street, | 112,000 | |
| At Crescent Street, | 112,000 | |
| At Perkins Avenue, | 102,000 | |
| At West Bridgewater, | 112,000 | |
| At South end Nippinicket Pond, | 102,000 | |
| At Raynham, | 110,000 | |
| At County Street, Taunton, | 119,000 | |
| At Weir Village, | 121,000 | |
| At Berkely bridge, | 111,000 | |
| | | 1,633,000 |
| *Railroad Bridges.* | | |
| South Shore branch, | $113,000 | |
| Whitman branch, | 113,000 | |
| Main line at Campello, | 302,000 | |
| New Bedford branch, | 117,000 | |
| Fall River branch, | 735,000 | |
| | | 1,380,000 |
| Dams, | | 170,000 |
| *Locks.* | | |
| Lock No. 1, | $575,000 | |
| Lock Nos. 2 and 3, | 2,281,000 | |
| Lock No. 4, | 731,000 | |
| Lock No. 5, | 866,000 | |
| Lock No. 6, | 866,000 | |
| Lock No. 7, | 662,000 | |
| Lock No. 8, | 662,000 | |
| Lock No. 9, | 706,000 | |
| Lock No. 10, | 706,000 | |
| Lock No. 11, | 796,000 | |
| Lock No. 12, | 706,000 | |
| Lock No. 13, | 706,000 | |
| Lock No. 14, | 570,000 | |
| Operating machinery, | 1,400,000 | |
| | | 12,233,000 |
| Lock approaches, | | 2,406,620 |
| Power and lighting plant, | | 220,000 |
| Water supply plant, | | 2,532,499 |
| Maintenance plant, | | 200,000 |
| Right of way (4,045 acres) and damages, | | 2,580,910 |
| Engineering and contingencies, 15 per cent., | | 7,515,438 |
| Total, | | $57,618,358 |

The work of preparing the report and estimates has been pushed with all practicable speed, and every effort has been made to have

the estimates as complete and accurate as possible with the information available; in order to do this, plans have been used before they were inked in and completed. The office force is still at work on them, but it will be some time before they are completed, and, with the field notes, put in proper shape to record and file away.

Two plans, one showing the location and the other the profile of the proposed canal line, are forwarded herewith, together with a diagram showing the standard cross-sections on which the estimates are based.

Respectfully,

FRANK W. HODGDON,
*Engineer.*